InSight

2018 Dust Storm Discussion

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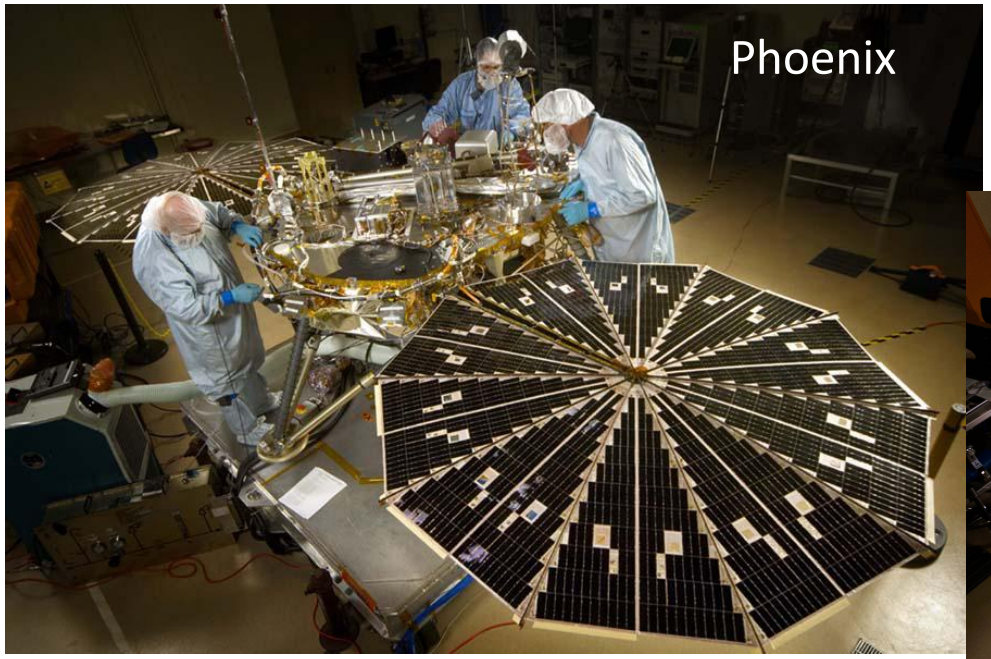
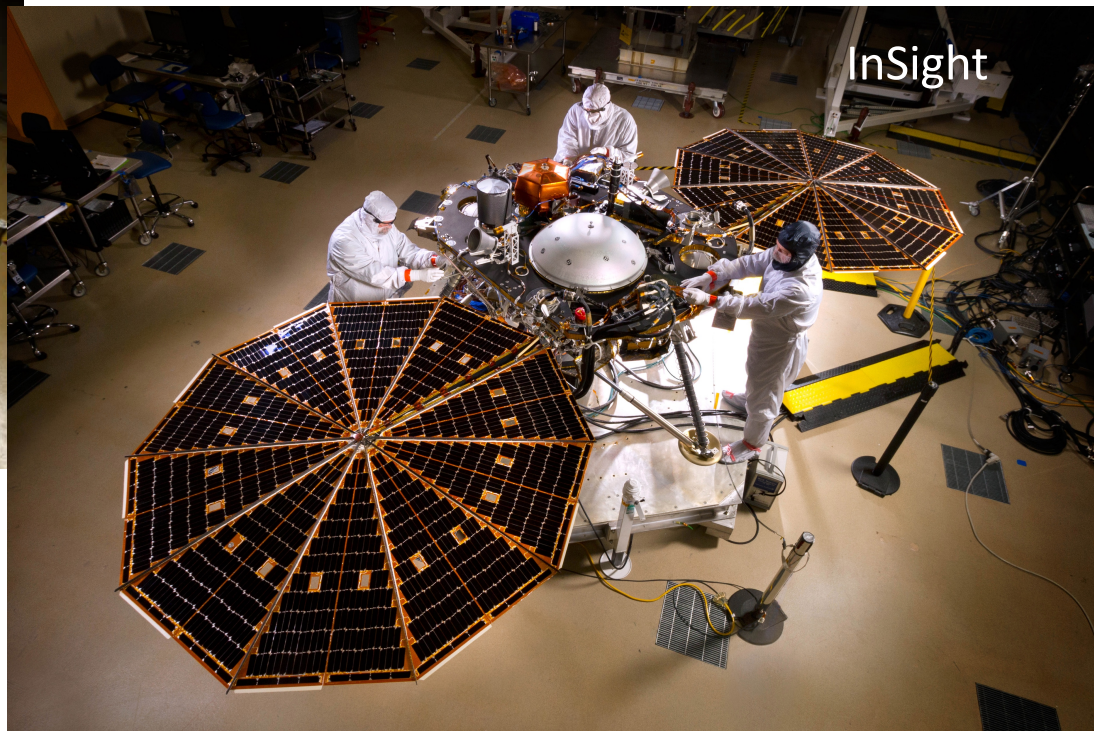
Phoenix in ATLO (2006-2007); InSight in ATLO 1.0 (2015)





Phoenix:
Solar-powered Lander
Must do science for 90 sols @ Martian pole
Surface mission not during dust storm season

InSight:
Solar-powered Lander
Must do science for a whole Martian year near equator
Long-term atmospheric opacity and dust accumulation a big driver

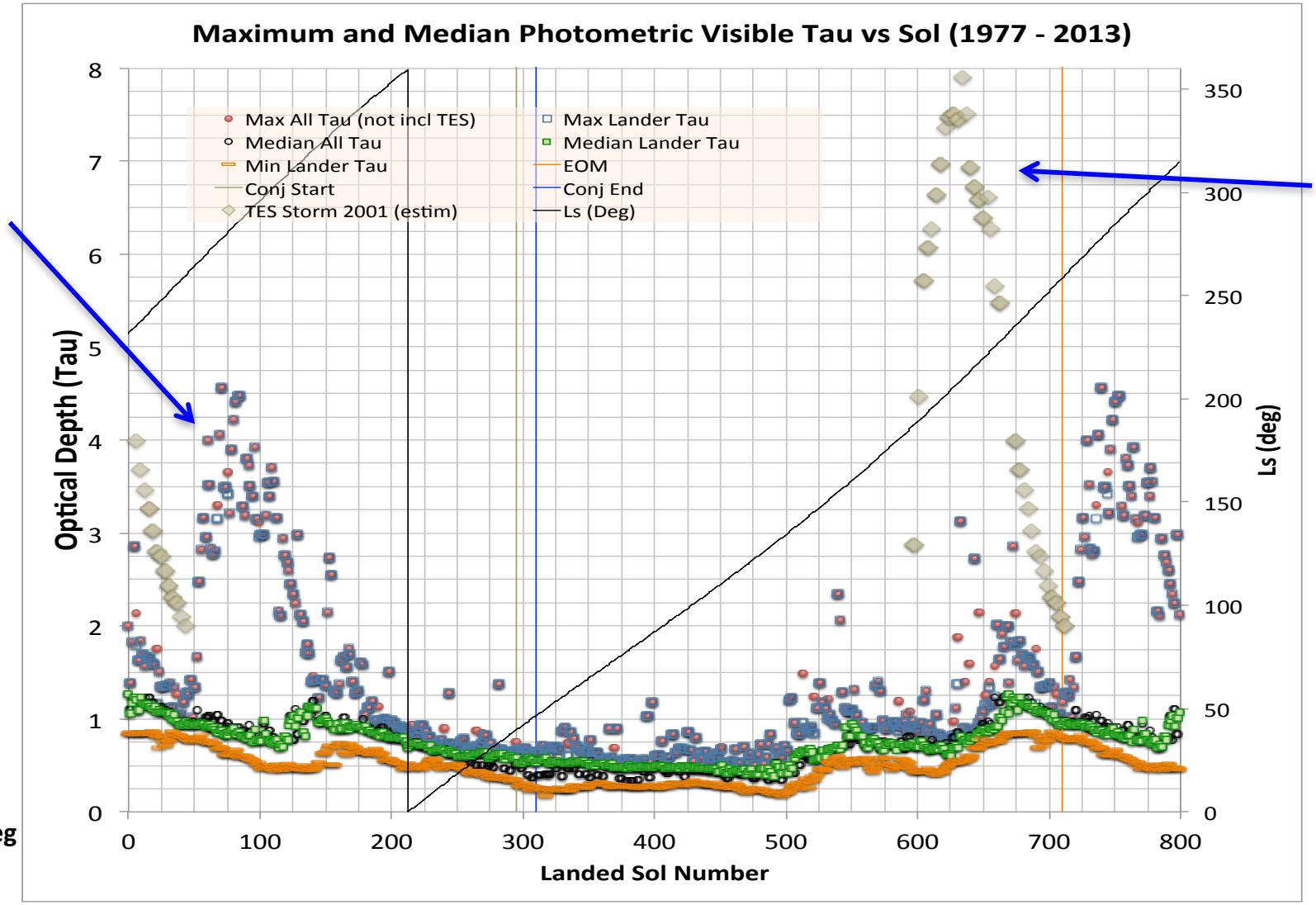
A Dust Storm Almanac

- In 2012 - soon after InSight was selected as a NASA Discovery mission - to help specify and size the power system, it was decided to assess all Mars dust storms for which we had archived measurements from either orbit or the surface.
  - Attempted to “spot calibrate” orbital IR down-looking opacity estimates where possible, with optical up-looking estimates made from the surface.
  - Even looked at pressure data from Viking landers (in addition to sun diode data), as well; attempted similar “spot calibrations” for it.
- Received data and feedback and information from many science colleagues including Mark Lemmon, David Kass, Michael Mischna, Matt Golombek, and Rich Zurek.
- Final database – called the “Dust Storm Almanac” – included tau data from landers (Vikings 1 and 2, Spirit and Opportunity), as well as orbital data (IRTM on Viking orbiter, TES on MGS, THEMIS on Mars Odyssey)
  - When Dust Storm Almanac was remapped for the 2018 arrival, also incorporated Curiosity tau data, provided courtesy of Mark Lemmon, and updated all statistics (e.g. max, min, median measured tau per value of Ls, tallies of measurements per sol).

Dust Storm Severity vs Ls (Dust Storm Almanac for 2016 Launch)

2007 MER Storm (northern winter)

2001 "TES" Storm (northern autumn)



Land:
Ls = 231.5 deg

- 2007 MER Storm is source of InSight 4.56 tau survival limit (w/ energy balance & margin)
- 2001 TES Storm, at tau of 8 or higher for weeks, not survivable by solar lander, so plan is to have <u>all data needed for threshold success collected by 120 sols before EOM</u>.

How the Dust Storm Almanac was used to Design InSight

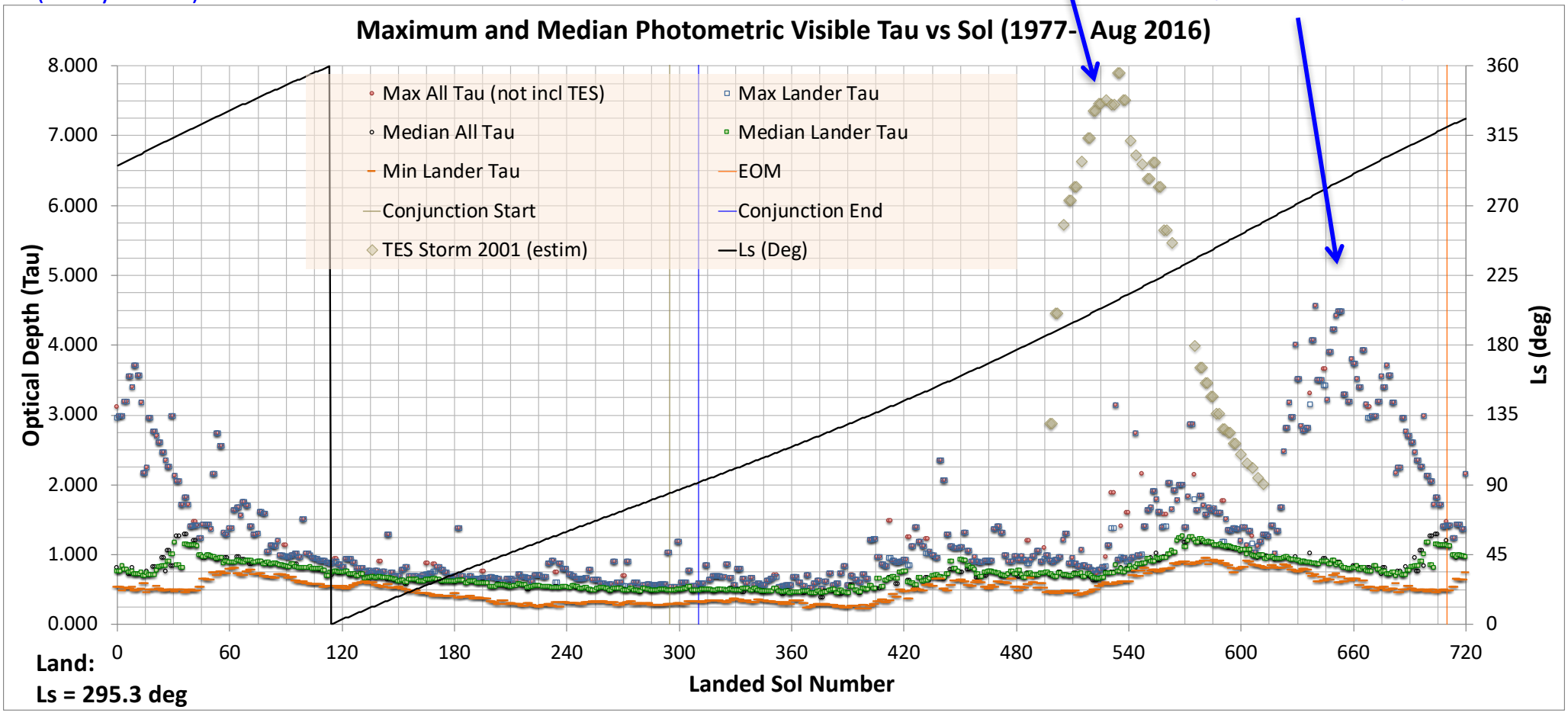
- Almanac was scanned for the points on the tau curves where power generation would be most hampered (max tau) as well as where heater activity could be large (min tau)
  - These became the power design points.
  - Used the tau values in power models, combined with conservative dust accumulation curve (assumes no wind clearing ever) and worst-value tilt of the solar arrays away from the sun.
  - Sized solar arrays and all power equipment including our batteries. Planned operating loads and allocations, using this data.
- Also used the max tau and min tau curves to generate our thermal environments via GCM run by Dr. Jim Murphy/NMSU.
  - Used to establish design conditions for our thermal enclosure, including sizing of its batt insulation and sizing of its operational and survival heaters.
  - The tau-modulated temperature data were used to develop our thermal requirements and also to plan the thermal test environments.
- Also used in ops planning - along with MER archived energy predicts (thanks to Jennifer Hermann of MER) - for surface energy management policies, but that's a long story for a different time.

Dust Storm Severity vs Ls (Dust Storm Almanac for 2018 Launch)

2007 MER Storm and Viking 1977b Storm (Decay Period)

2001 "TES" Storm

2007 MER Storm and Viking 1977b Storm (northern winter)



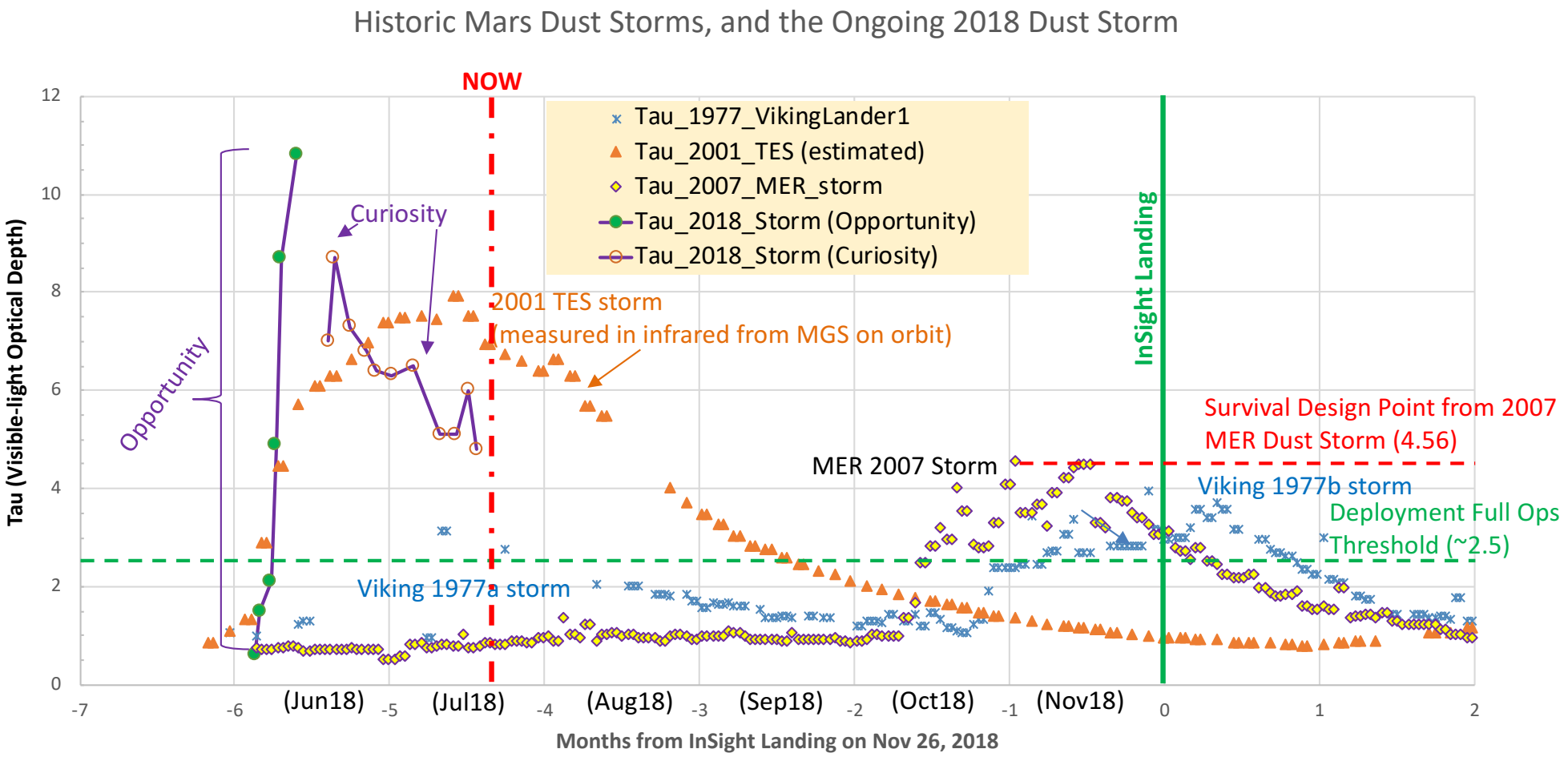
- 2007 MER Storm peak now occurs at end of our mission, within by 120 sols before EOM.
- Peak of the 2001 TES Storm would not be survivable for our solar-powered lander, if it took place during our surface mission.
- What if the 2001 storm occurred in the months *before* we landed? See next slides.

Lisano

About the Current Global Storm

- On around June 6, Opportunity Rover experienced a sharp upturn in tau
- Orbital images from MARCI (Bruce Cantor, MSSS) showed an intense regional dust storm sweeping into Meridiani
- By June 10, tau at Opportunity had risen to 10.8 (according to Mark Lemmon) – then we heard no more from Opportunity.
- MCS reports by David Kass, online MARCI reports by Bruce Cantor, and also Mark Lemmon's frequent surface tau reports from Gale Crater (on a fortuitously-placed, plutonium-powered tau-measuring machine called "Curiosity") have kept us up to speed on this storm, which has become planet-encircling (i.e. "global"). Storm is still active today (7/12).
  – Expectation of such storms is that they last 2-3 months.
- Comparison with sections of Dust Storm Almanac Data on the next page.

2018 Storm vs Other Storms, In Seasons They Occurred



- *Tau data from MER and Curiosity courtesy of Mark Lemmon; Tau data from TES courtesy of David Kass.*
- The current 2018 storm (purple curve) rose up with similar seasonal timing and rate as the global storm of 2001.
- InSight lands after the 2018 storm has likely faded below InSight's survival design point.
- Still-elevated tau levels when InSight lands result in either safe mode or slower-paced deployment.

Remarks on Operating Conditions in Tail of Big Storm

- Project is watching this storm carefully, getting regular reports from Lemmon & Kass.
  - Expectation is that opacity will *very* likely have faded to safe operating levels by late November – even earlier by “eyeball” comparison with tau record from the 2001 storm.
- Dust accumulation rate on the solar arrays, in storm’s aftermath, poses a concern for InSight.
  - That rate depends on where we are, timewise, in the post-storm decay period, and how much wind cleaning we get at Elysium.
  - Our ERD has a heavy dust factor, more conservative than ~98% of MER’s first 800 sols, and further, assumes no wind cleaning.
  - Fallout at Spirit, post-07-storm, was worse than our ERD. Spirit got no cleanings for about a Mars year, and her solar panels lost > 70% insolation due to dust accumulation (i.e. dust factor < 0.3).
    - Opportunity, however, got fairly frequent wind cleanings post-2007 storm, and did not suffer from hampered power the way Spirit did.